

# REVERSE LOGISTICS: A REVIEW OF LITERATURE

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## Abstract

This paper reviews the practice in reverse logistics through published literature. The objective of this study is to encourage and provide researchers with future research directions in reverse logistics. Since supply chains are designed for forward flow, integrating product recovery into the network design poses a major challenge. An important assignment of top management is to analyse the obstacles of reverse logistics which could be vital to the survival of the industry in the future.

**Keywords:** Reverse logistics, Multi-criteria, Decision making, Network design

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## 1. INTRODUCTION

Environmental awareness and recycling regulations have been putting pressure on many manufacturers and consumers to dispose used products in an environmentally responsible manner. Reverse logistics (RL) is a part of a broader supply chain management process called returns management. A complete supply chain should include both forward logistics and reverse logistics. Forward logistics operations subsequently increase the reverse logistics activities and thus it plays an important role in the organization success [1]. Researchers have reported several benefits that could be achieved with RL, namely efficient resource utilization and environmental protection [2,3].

Due to the interdisciplinary and cross functional nature of reverse logistics, it provides a fertile and attractive research area in the field of operations management [4]. Sheriff et al., [5] develop a framework to classify the various issues/parameters affecting strategic level decisions in reverse logistics. Dowlatshahi [6] propose a framework for effective design and implementation of reverse logistics operations. An extensive review of research on reverse logistics is presented [7,8, 9].

## 2. DECISION MAKING IN RL

A conceptual framework for managing retail reverse logistics operation is presented in [10]. In the case study conducted by [11], three companies were visited and identified reverse logistics process flow and the strategic issues a firm may use for competitive advantage. A model for green supply chain management with incomplete information is developed [12]. Reverse logistics is suggested as an area for future research and the advantages are discussed [13]. A dynamic model is constructed and validated using the data collected from the computer company [14]. A distribution system which uses a combination of manufacturing and remanufacturing is proposed and the models are compared with respect to the various prices [15].

A pricing decisions model for a fuzzy closed-loop supply chain with retail competition in the marketplace was considered in [16]. Delphi method is applied to differentiate the criteria for evaluating traditional suppliers and green suppliers [17, 18]. Dat et al., [19] presents a mathematical programming model which minimizes the total processing cost of multiple types of waste electrical & electronic products. Pochampully and Gupta [20] use fuzzy AHP in a reverse supply chain to select the most economical product to be reprocessed and the potential recovery facilities.

Büyüközkan and Çifçi [21] propose a hybrid fuzzy multi-criteria decision making model for evaluating green suppliers. Ravi, et al., [4] propose a combination of balanced scorecard and analytic network process to provide a more realistic and accurate representation for conducting reverse logistics operations for end-of-life computers. Fernández and Kekale [3] propose a conceptual model using Delphi and AHP as an aid to determine which variables caused reverse logistics success. However AHP & ANP have weakness in the number of pairwise comparisons required could become cumbersome. Biehl et al., [22] simulate a carpet RL supply chain which uses a designed experiment to analyze the impact of the system design factors on the operational performance of the RL system. Pochampally and Gupta [23] propose a TOPSIS-based methodology to rate candidate companies that collect and sell used products.

Rahman and Subramanian [24] use the cognition mapping process to identify the critical factors in designing and implementing end-of-life (EOL) computer recycling operations in reverse logistics. Vachon [25] analyses the relationship between environmental collaboration and environmental monitoring in a supply chain. Ramirez [26] indicates that managing cost returns influences the organizational performance.

## 3. SELECTION OF RL PROVIDER

Byrne [27] indicates that 86 per cent of RL decision makers believe that outsourcing gave them more control over their

operations and 55 per cent of RL decision makers believe that outsourcing assisted them to implement changes faster and more effectively. By outsourcing reverse logistics activities, the organizations can concentrate on their core business operation, but customer satisfaction and delivery performance may be improved. Kannan & Murugesan [28] present fuzzy extent analysis for selecting third-party reverse logistics provider for the battery industry. Azadi & Saen [29] propose a chance-constrained data envelopment analysis for selection in the presence of dual role factors. Zhihong and Qiang [30] present a grey comprehensive model based on AHP and grey relational analysis for the selection of RL providers. Meade and Sarkis [31] propose analytical network process model for the reverse logistics provider selection. However the number of pairwise comparison required could become cumbersome. Efendigil et al., [32] propose artificial neural network and fuzzy analytical hierarchy process to select the third party logistics provider in the presence of vagueness.

Amin and Zhang [33] present an integrated model for supplier selection, order allocation, and closed loop network configuration. Xiangru [34] evaluate third party reverse logistics provider (3PRLP) with fuzzy comprehensive evaluation method. Govindan et al. [1] develop a model using interpretive structural modeling (ISM) to analyze the relationship among the attributes of 3PRLP. However the model has not been statistically validated. Kannan et al., [35] use ISM and fuzzy TOPSIS for the selection of reverse logistics provider. Sasikumar and Haq [36] propose the fuzzy VIKOR method and integrated the distribution network to 3PRLP selection. Saen [37] use data envelopment analysis in the presence of multiple dual roles for selecting third party reverse logistics provider.

#### 4. REVERSE LOGISTICS NETWORK DESIGN

The design of reverse logistics network is a difficult problem because of its economic aspects and its effects on other aspects of human life, namely, the environment and sustainability of natural resources [38,39]. Logistics network design problems that take into account the facility locations and the shipment of the product flows have been considered in the past.

Pishvae et al., [40] develop a new hybrid credibility based fuzzy mathematical programming for green logistics network design. Lee et al., [41] use genetic algorithm for solving a three stage reverse logistics network model for minimizing the total cost. A mathematical model for the design of reverse logistics network design is proposed [42,43,44] considering the location and allocation of facilities. An integrated forward logistics multi echelon distribution inventory supply chain model and closed loop multi echelon distribution for the built to order environment is designed using genetic algorithm and particle swarm optimization [45].

Figueiredo and Mayerle [46] present a conceptual framework, an analytical model, and a three-stage algorithmic solution for solving designing minimum-cost recycling networks

with required throughput. The proposed network structure consists of three echelons in the forward direction and two echelons, in the reverse direction. Vahdani et al. [47] propose a novel model for designing a reliable network of facilities in closed-loop supply chain under uncertainty. Many researchers have investigated the various issues in a deterministic environment. Kroon and Vrijens [48] have considered the design of a logistics system for used plastic containers. They propose a mixed integer linear programming model to determine the number of containers required to run a five echelon system under consideration with an appropriate service, distribution and collection fee per shipment for empty containers and location of depots for empty containers. Piplani and Saraswat [49] propose a mixed-integer linear programming for optimizing the reverse logistics network to minimise the total cost. Mishra et al., [50] propose a multi-agent architecture to handle recycling and reverse logistics and to facilitate the efficient logistics of materials between different units.

Multi-objective optimization models have been developed for the design of reverse logistics network [51, 52]. Some researchers have modelled the reverse logistics network design problems under uncertainty. Lieckens and Vandaele [53] propose a planning model with integrated quality routing that explicitly takes into account stochastic delays. Ramezani [54] present a stochastic multi-objective model for forward/reverse logistics under uncertain environment. The objectives considered are maximization of profit, customer responsiveness, quality. The set of Pareto-optimal solutions is obtained and the financial risk is also computed. The summary of articles in reverse logistics is shown in Table 1.

**Table -1: Summary of articles in reverse logistics**

Sl. No	Reference	Topic	Material in	Material out
1	[55]	Reverse logistics networks	Recyclables in general	Materials
2	[56]	Purchase of recycled materials	Paper	Paper
3	[57]	Logistic implications of recycling programs	Recyclables in general	Materials
4	[58]	Planning and control of recovery activities	Glass scrap	Raw materials
5	[59]	Reverse logistics network	House hold waste	Substitutes for primary material
6	[60]	Incentives to	Batteries	Materials

		stimulate recovery		
7	[61]	Reverse logistics network	Steel products	reusable products
8	[62]	Incentives to stimulate recovery	Batteries	Raw materials Batteries
9	[63]	Reverse logistics networks	Construction waste	Sand
10	[64]	Information and Communication for reverse logistics	End-of-use Refrigerators	Plastics Metals
11	[65,66]	Reverse logistics networks	Carpets	Fibres

## 5. CONCLUSIONS

This paper presents a review of literature in reverse logistics. Several extensions are possible in reverse logistics. We could also study the case with competition between manufacturing and remanufacturing processes, namely, the manufacturing and remanufacturing taken by different firms. User friendly and smart decision support system may also be developed. Probabilistic demand pattern may also be considered in future studies.

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